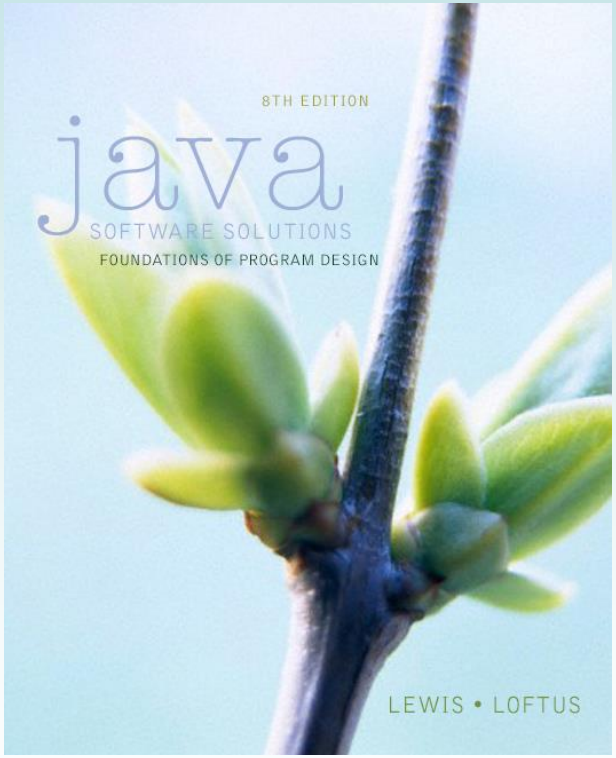
Chapter 1
Introduction



Java Software Solutions
Foundations of Program Design
8th Edition

John Lewis
William Loftus

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Focus of the Course

- Object-Oriented Software Development
  - problem solving
  - program design, implementation, and testing
  - object-oriented concepts
    - classes
    - objects
    - encapsulation
    - inheritance
    - polymorphism
  - graphical user interfaces
  - the Java programming language

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Introduction

- We start with the fundamentals of computer processing
- Chapter 1 focuses on:
  - components of a computer
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages
  - an introduction to Java
  - an overview of object-oriented concepts

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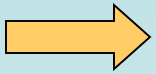
Outline



Computer Processing

Hardware Components

Networks

The Java Programming Language

Program Development

Object-Oriented Programming

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Hardware and Software

- Hardware
  - the physical, tangible parts of a computer
  - keyboard, monitor, disks, wires, chips, etc.
- Software
  - programs and data
  - a *program* is a series of instructions
- A computer requires both hardware and software
- Each is essentially useless without the other

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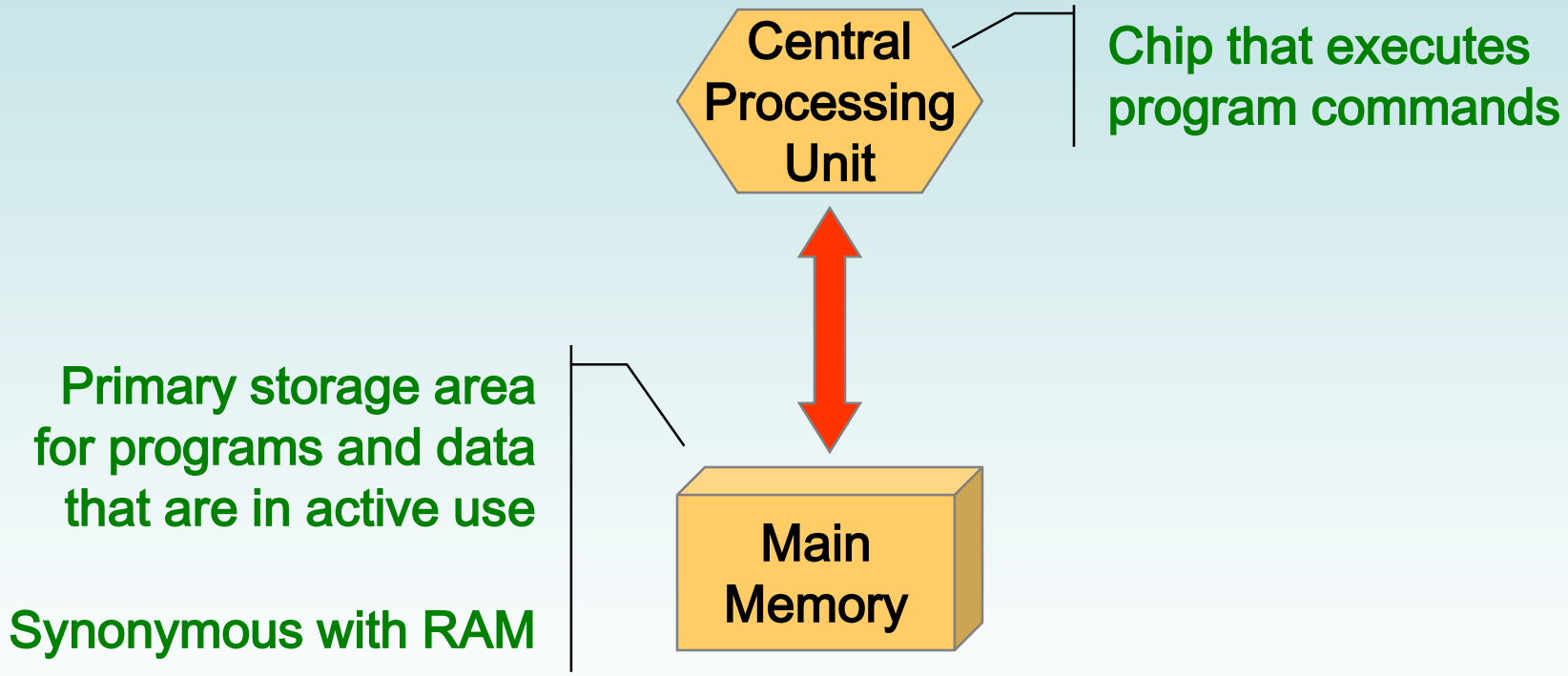
CPU and Main Memory


Central Processing Unit
Chip that executes program commands
Primary storage area for programs and data that are in active use
Synonymous with RAM
Main Memory

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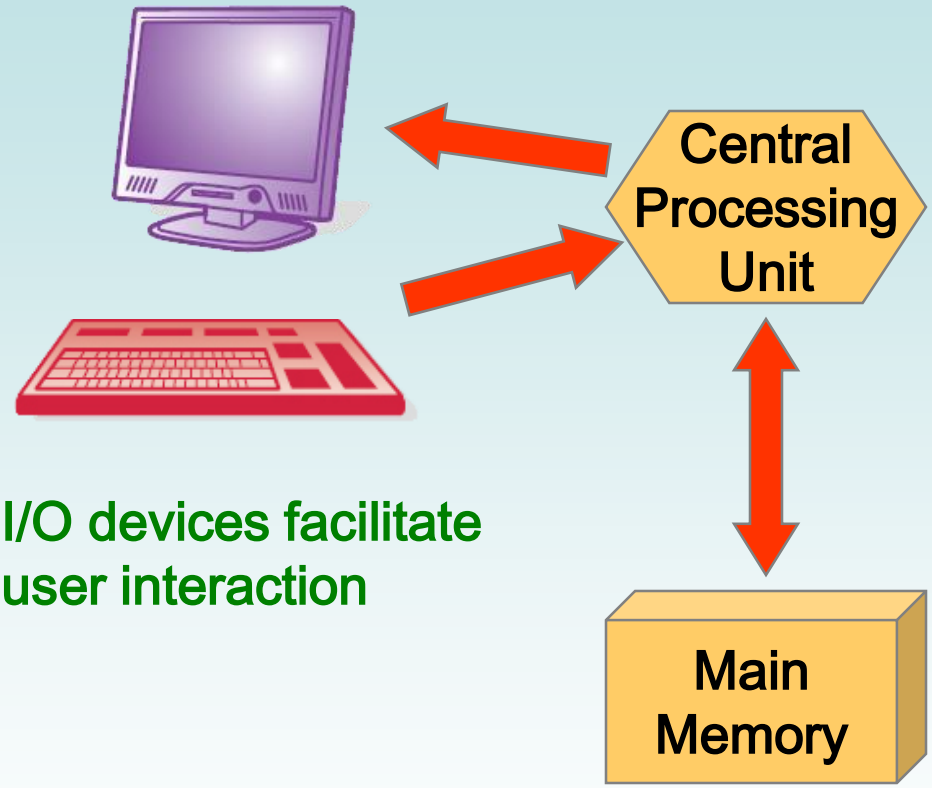
Input / Output Devices



I/O devices facilitate user interaction

Monitor screen
Keyboard
Mouse
Touch screen

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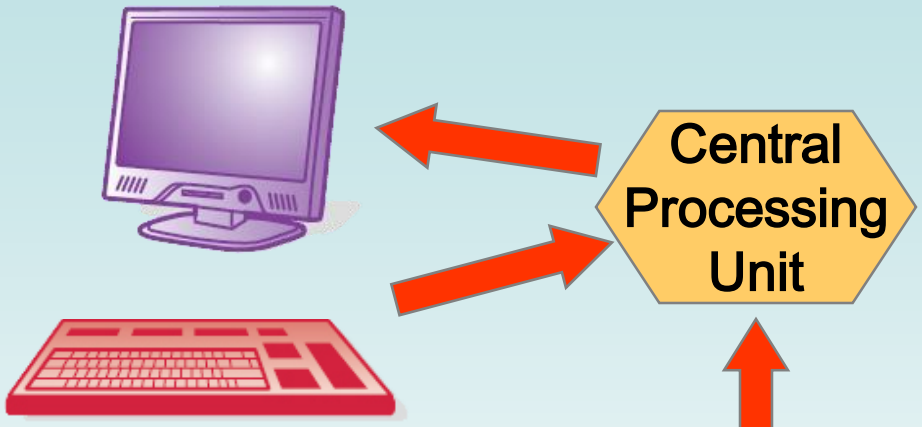
Secondary Memory Devices



Central Processing Unit

Information is moved between main and secondary memory as needed

Hard Disk

Main Memory

USB Flash Drive

Secondary memory devices provide long-term storage

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Software Categories

- Operating System
  - controls all machine activities
  - provides the user interface to the computer
  - manages resources such as the CPU and memory
  - Windows, Mac OS, Unix, Linux,
- Application program
  - generic term for any other kind of software
  - word processors, missile control systems, games
- Most operating systems and application programs have a *graphical user interface* (GUI)

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Analog vs. Digital

- There are two basic ways to store and manage data:
- *Analog*
  - continuous, in direct proportion to the data represented
  - music on a record album - a needle rides on ridges in the grooves that are directly proportional to the voltages sent to the speaker
- *Digital*
  - the information is broken down into pieces, and each piece is represented separately
  - *sampling* – record discrete values of the analog representation
  - music on a compact disc - the disc stores numbers representing specific voltage levels sampled at specific times

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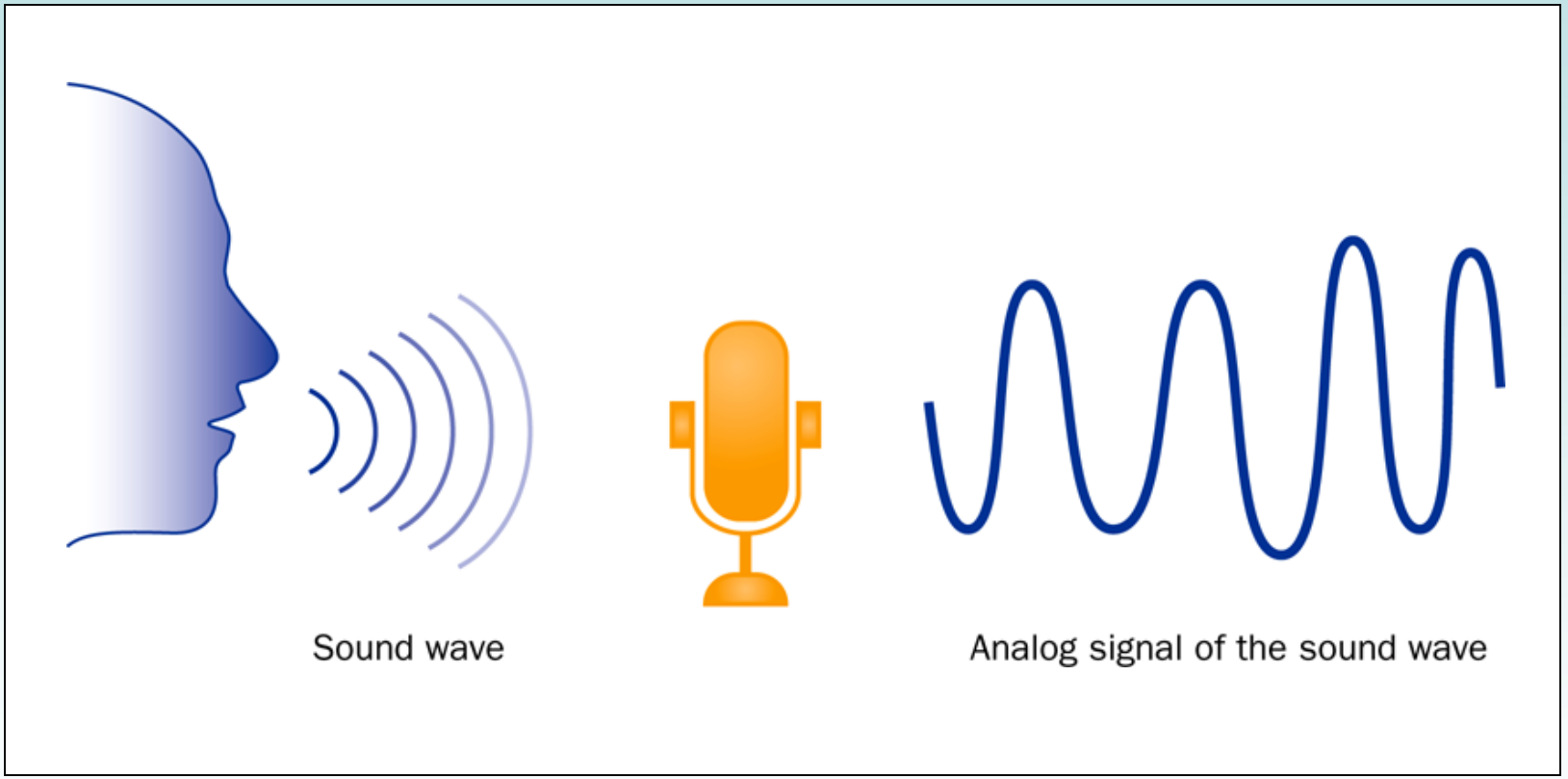
Analog Information



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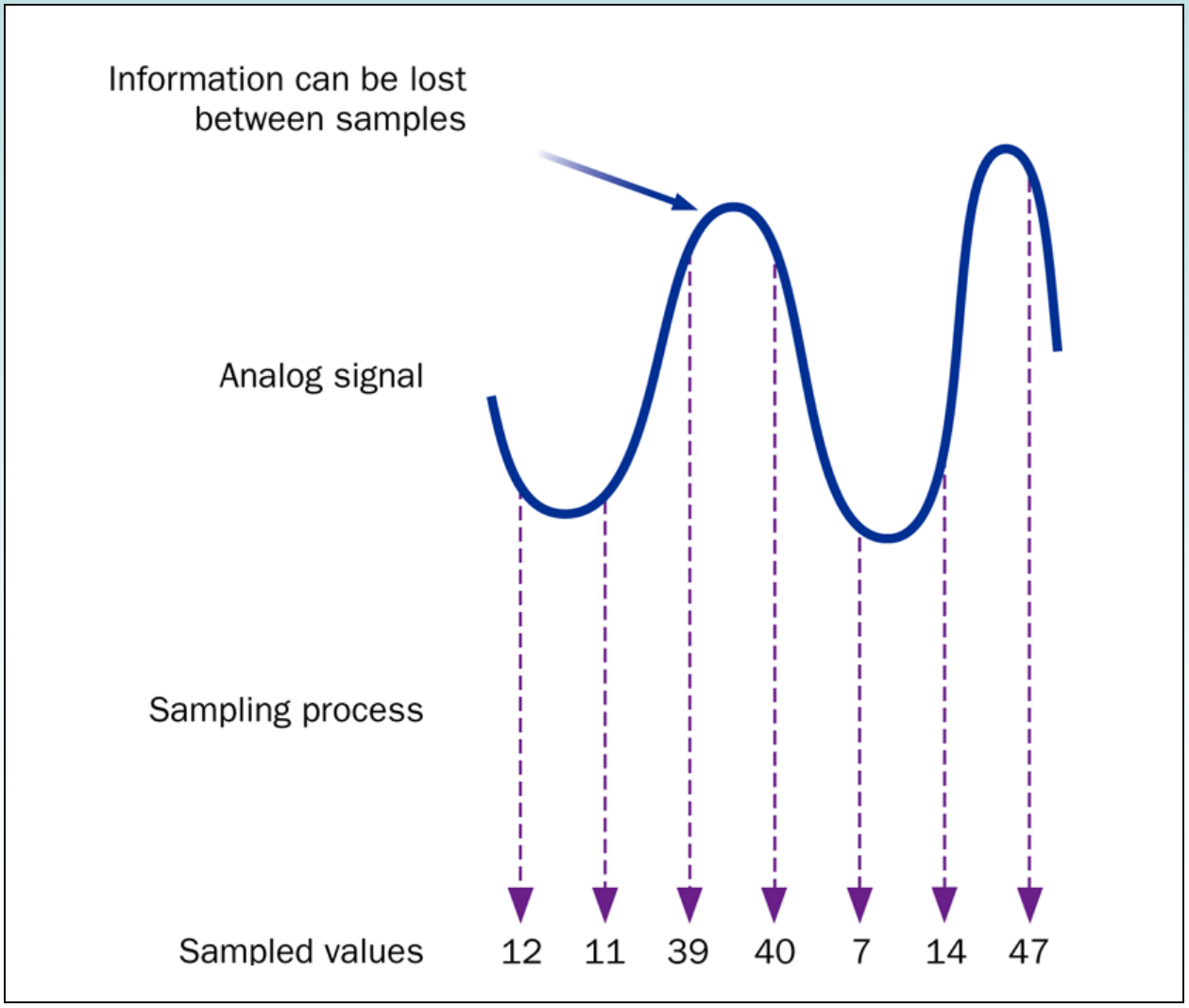
Sampling



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Digital Information

- Computers store all information digitally:
  - numbers
  - text
  - graphics and images
  - audio
  - video
  - program instructions
- In some way, all information is *digitized* - broken down into pieces and represented as numbers

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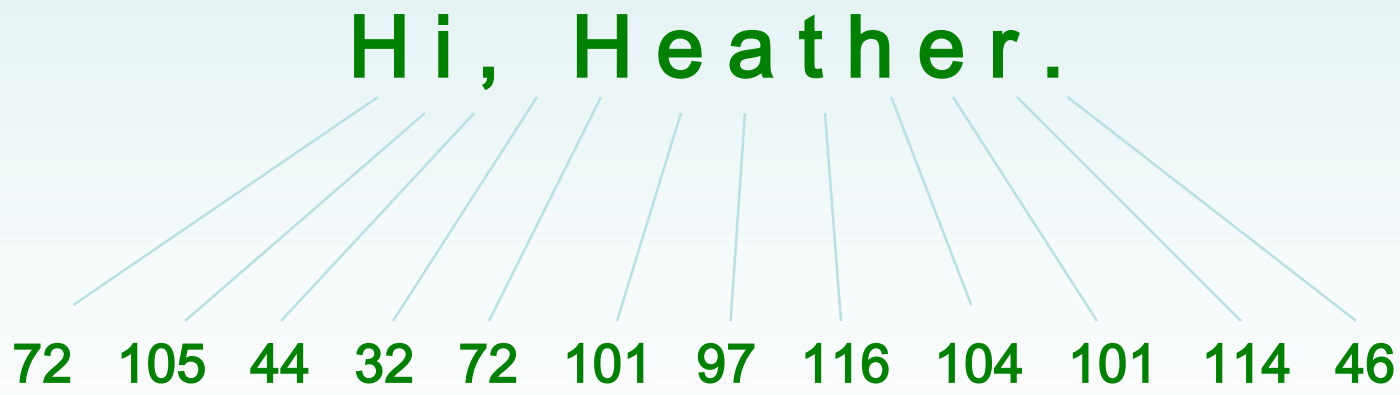
Representing Text Digitally

- For example, every character is stored as a number, including spaces, digits, and punctuation
- Corresponding upper and lower case letters are separate characters



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Binary Numbers

- Once information has been digitized, it is represented and stored in memory using the *binary number system*
- A single binary digit (0 or 1) is called a *bit*
- Devices that store and move information are cheaper and more reliable if they have to represent only two states
- A single bit can represent two possible states, like a light bulb that is either on (1) or off (0)
- Permutations of bits are used to store values

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Bit Permutations

1 bit	2 bits	3 bits	4 bits	
0	00	000	0000	1000
1	01	001	0001	1001
	10	010	0010	1010
	11	011	0011	1011
		100	0100	1100
		101	0101	1101
		110	0110	1110
		111	0111	1111

Each additional bit doubles the number of possible permutations

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Bit Permutations

- Each permutation can represent a particular item
- There are 2^N permutations of N bits
- Therefore, N bits are needed to represent 2^N unique items

How many items can be represented by

1 bit ?	$2^1 = 2$ **items**
2 bits ?	$2^2 = 4$ **items**
3 bits ?	$2^3 = 8$ **items**
4 bits ?	$2^4 = 16$ **items**
5 bits ?	$2^5 = 32$ **items**

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Quick Check

How many bits would you need to represent each of the 50 United States using a unique permutation of bits?

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Quick Check

How many bits would you need to represent each of the 50 United States using a unique permutation of bits?

Five bits wouldn't be enough, because 2^5 is 32.

Six bits would give us 64 permutations, and some wouldn't be used.

000000 Alabama
000001 Alaska
000010 Arizona
000011 Arkansas
000100 California
000101 Colorado

etc.

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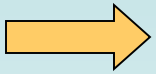
Outline



Computer Processing

Hardware Components

Networks

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Program Development

Object-Oriented Programming

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A Computer Specification

- Consider the following specification for a personal computer:
  - 3.07 GHz Intel Core i7 processor
  - 4 GB RAM
  - 750 GB Hard Disk
  - 16x Blu-ray / HD DVD-ROM & 16x DVD+R DVD Burner
  - 17” Flat Screen Video Display with 1280 x 1024 resolution
  - Network Card

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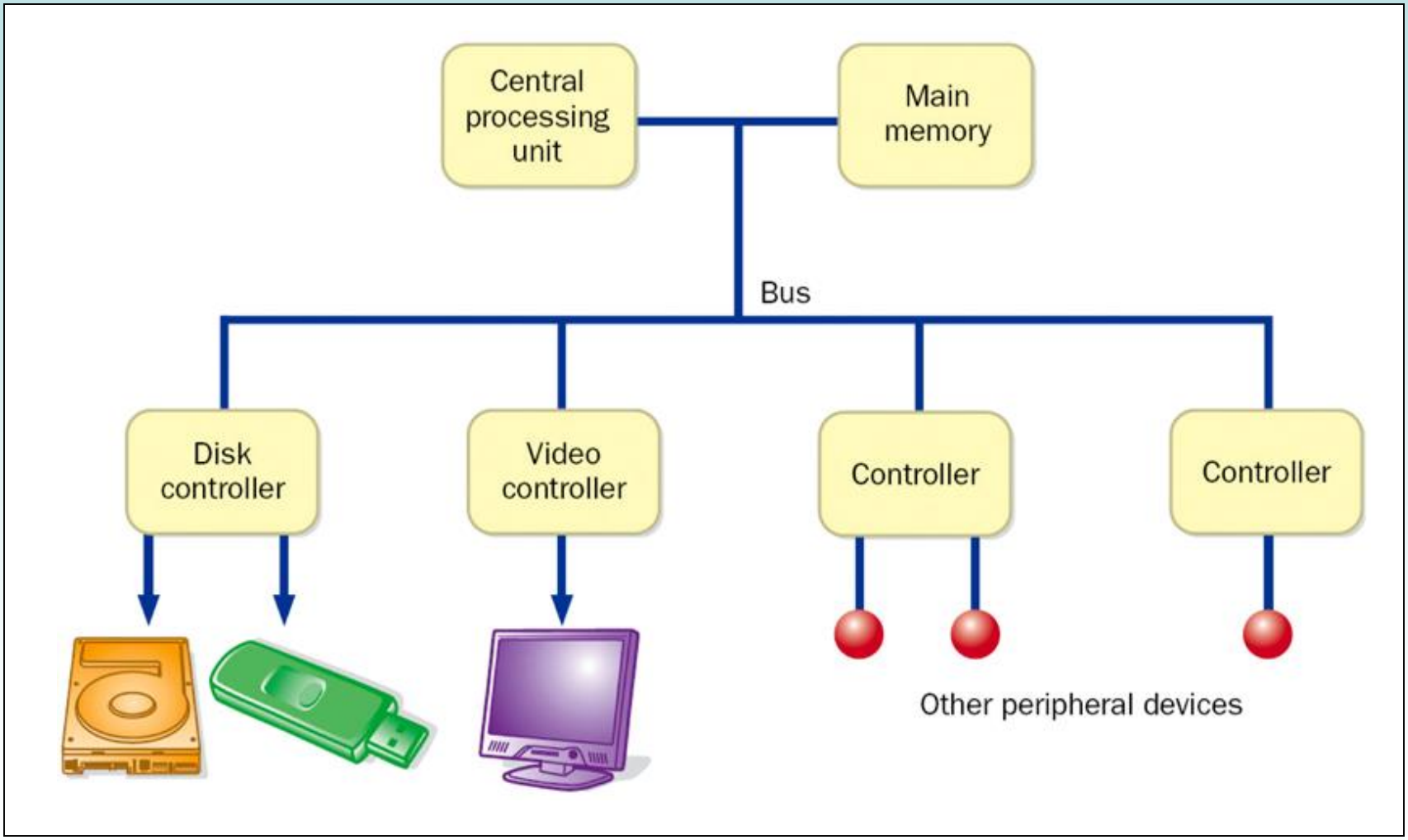
Computer Architecture



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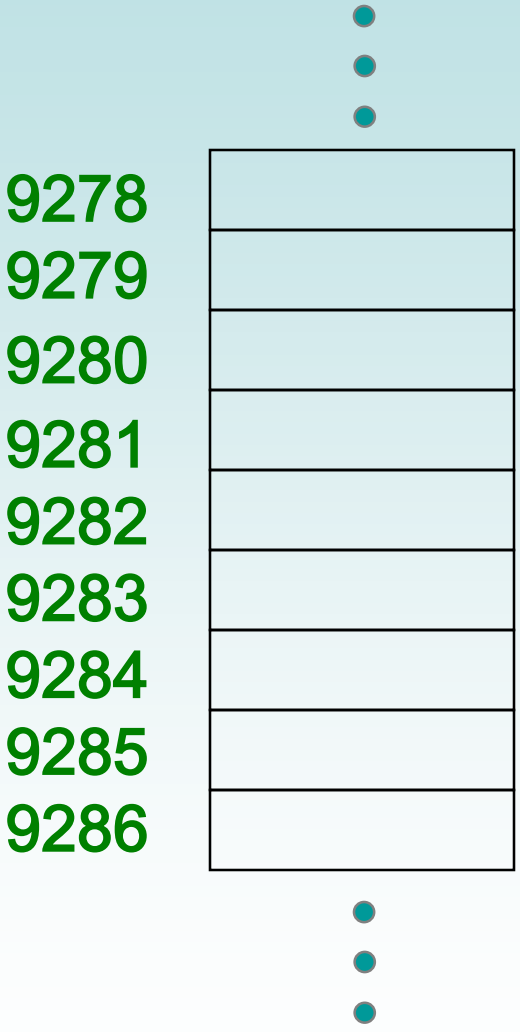
Memory



Main memory is divided into many memory locations (or *cells*)

Each memory cell has a numeric *address*, which uniquely identifies it

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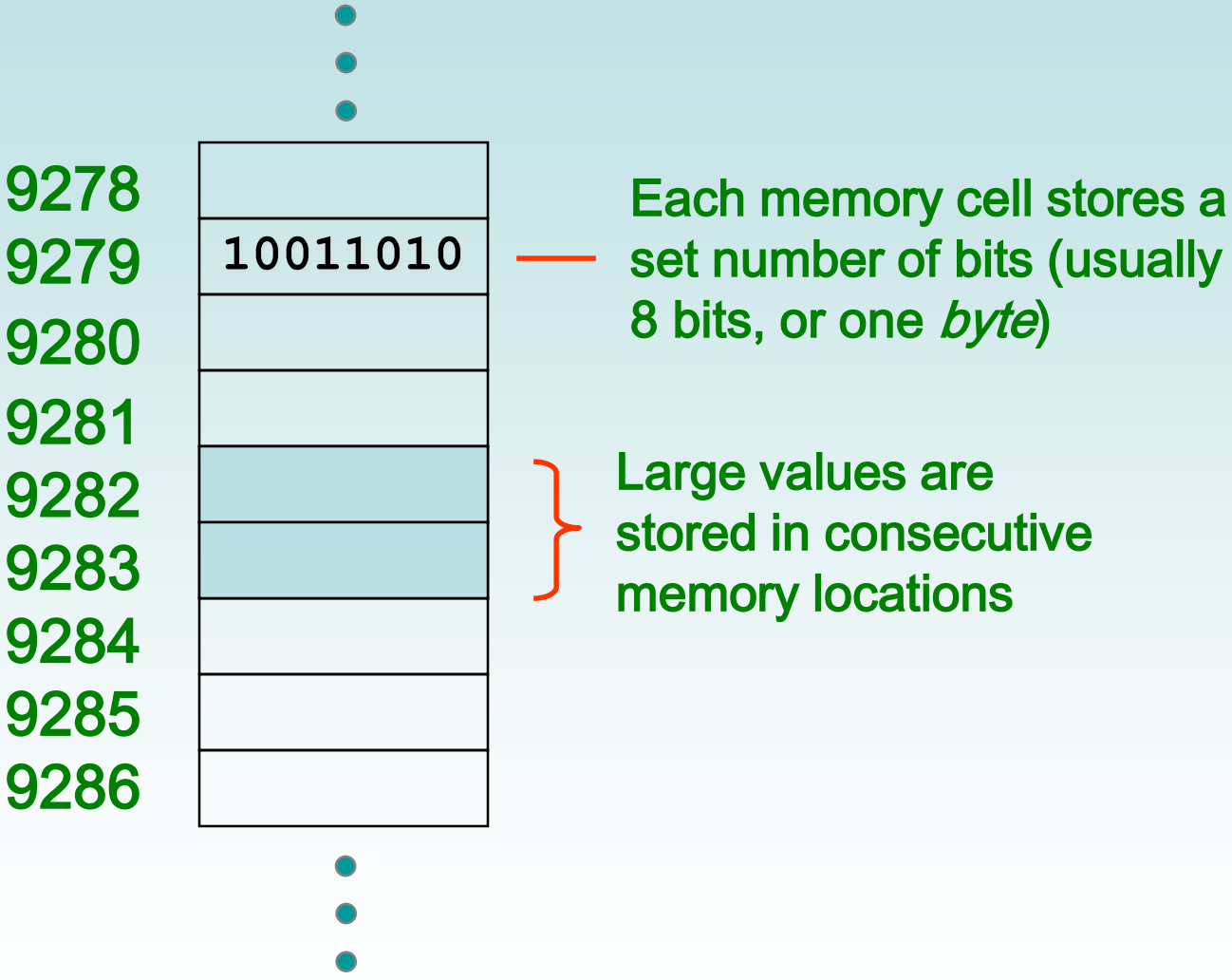
Storing Information



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Storage Capacity

- Every memory device has a *storage capacity*, indicating the number of bytes it can hold
- Capacities are expressed in various units:

Unit	Symbol	Number of Bytes
kilobyte	KB	2^{10} = 1024
megabyte	MB	2^{20} (over one million)
gigabyte	GB	2^{30} (over one billion)
terabyte	TB	2^{40} (over one trillion)
petabyte	PB	2^{50} (a whole bunch)

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Memory

- Main memory is *volatile* - stored information is lost if the electric power is removed
- Secondary memory devices are *nonvolatile*
- Main memory and disks are *direct access* devices - information can be reached directly
- The terms *direct access* and *random access* often are used interchangeably
- A magnetic tape is a *sequential access* device since its data is arranged in a linear order - you must get by the intervening data in order to access other information

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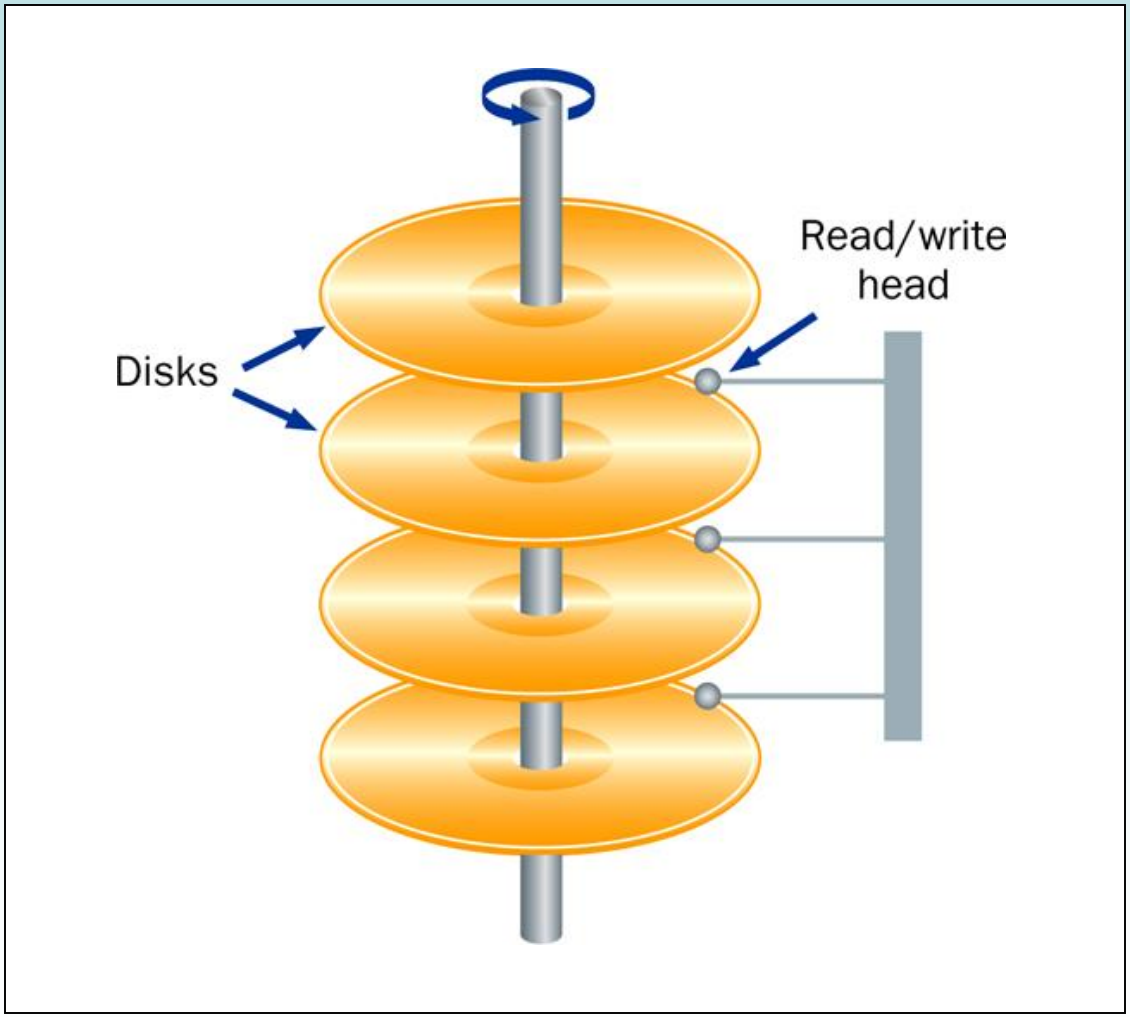
Hard Disk Drive



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RAM vs. ROM

- *RAM* - Random Access Memory (direct access)
- *ROM* - Read-Only Memory
- The terms RAM and main memory are basically interchangeable
- ROM could be a set of memory chips, or a separate device, such as a CD ROM
- Both RAM and ROM are random (direct) access devices!
- RAM probably should be called Read-Write Memory

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Compact Discs

- A CD-ROM is portable read-only memory
- A microscopic pit on a CD represents a binary 1 and a smooth area represents a binary 0
- A low-intensity laser reflects strongly from a smooth area and weakly from a pit
- A CD-Recordable (CD-R) drive can be used to write information to a CD once
- A CD-Rewritable (CD-RW) can be erased and reused
- The speed of a CD drive indicates how fast (max) it can read and write information to a CD

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DVDs

- A DVD is the same physical size as a CD, but can store much more information
- The format of a DVD stores more bits per square inch
- A CD can store 650 MB, while a standard DVD can store 4.7 GB
  - A double sided DVD can store 9.4 GB
  - Other advanced techniques can bring the capacity up to 17.0 GB
- Like CDs, there are DVD-R and DVD-RW discs

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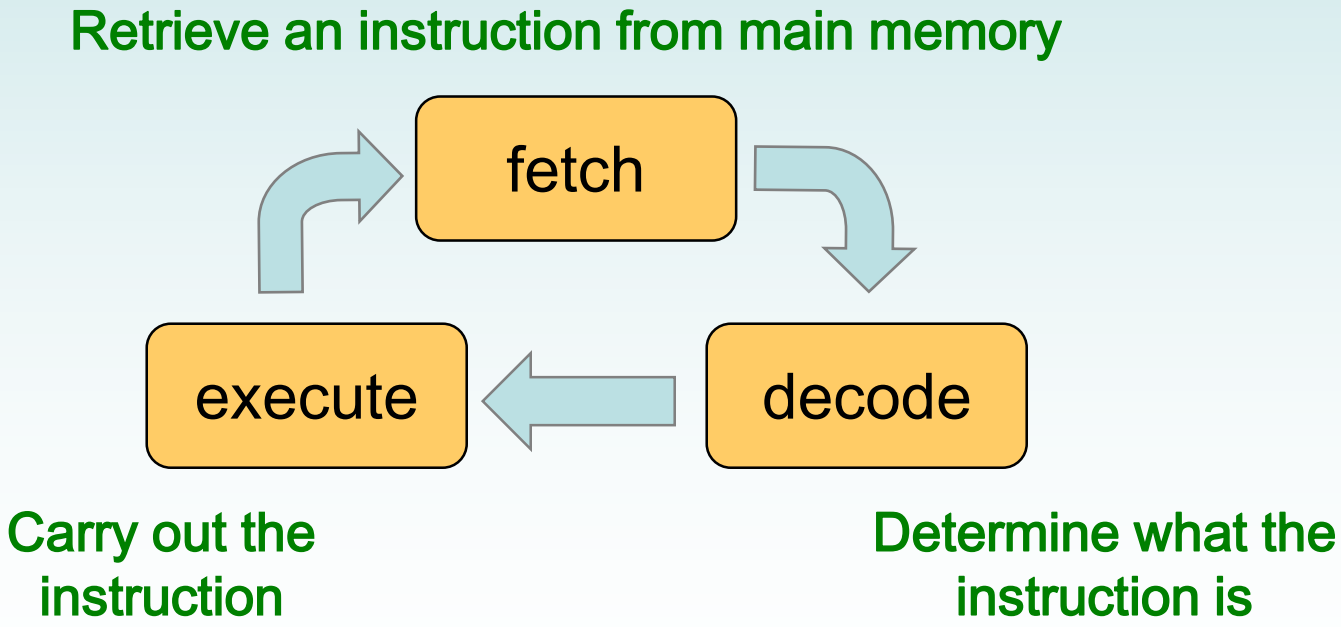
The Central Processing Unit

- A CPU is on a chip called a *microprocessor*
- It continuously follows the *fetch-decode-execute cycle:*



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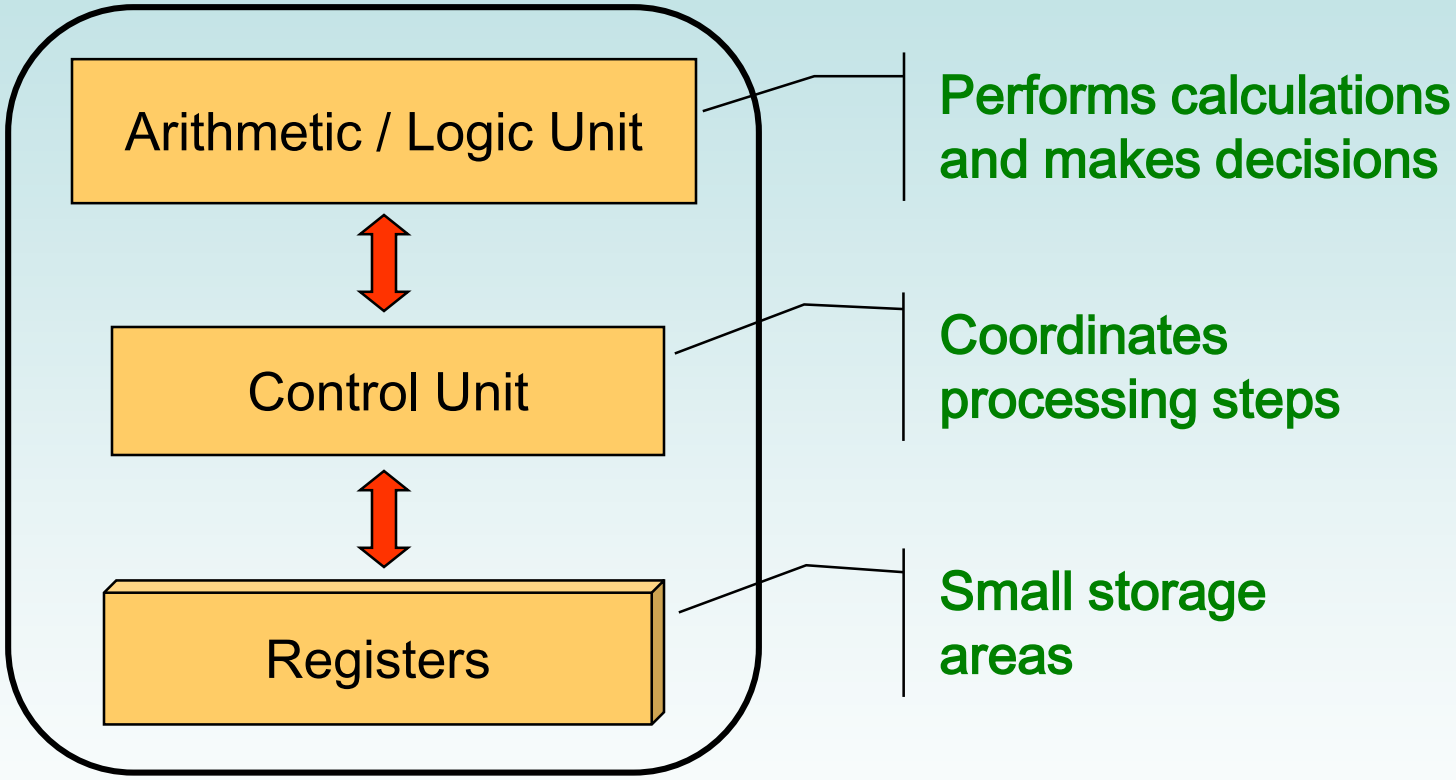
The Central Processing Unit



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The Central Processing Unit

- The speed of a CPU is controlled by the *system clock*
- The system clock generates an electronic pulse at regular intervals
- The pulses coordinate the activities of the CPU
- The speed is usually measured in *gigahertz* (GHz)

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Monitor

- The size of a monitor (17") is measured diagonally, like a television screen
- A monitor has a certain maximum *resolution* , indicating the number of picture elements, called *pixels*, that it can display (such as 1280 by 1024)
- High resolution (more pixels) produces sharper pictures

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Networks

- A *network* is two or more computers that are connected so that data and resources can be shared
- Most computers are connected to some kind of network
- Each computer has its own *network address*, which uniquely identifies it among the others
- A *file server* is a network computer dedicated to storing programs and data that are shared among network users

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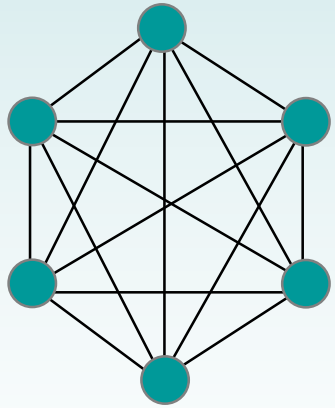
Network Connections

- Each computer in a network could be directly connected to every other computer in the network
- These are called *point-to-point* connections

Adding a computer requires a new communication line for each computer already in the network



This technique is not practical for more than a few close machines

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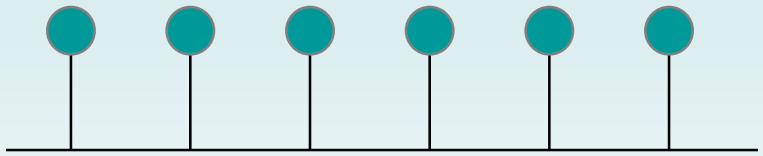
Network Connections

- Most networks share a single communication line
- Adding a new computer to the network is relatively easy



Network traffic must take turns using the line, which introduces delays

Often information is broken down in parts, called *packets*, which are sent to the receiving machine and then reassembled

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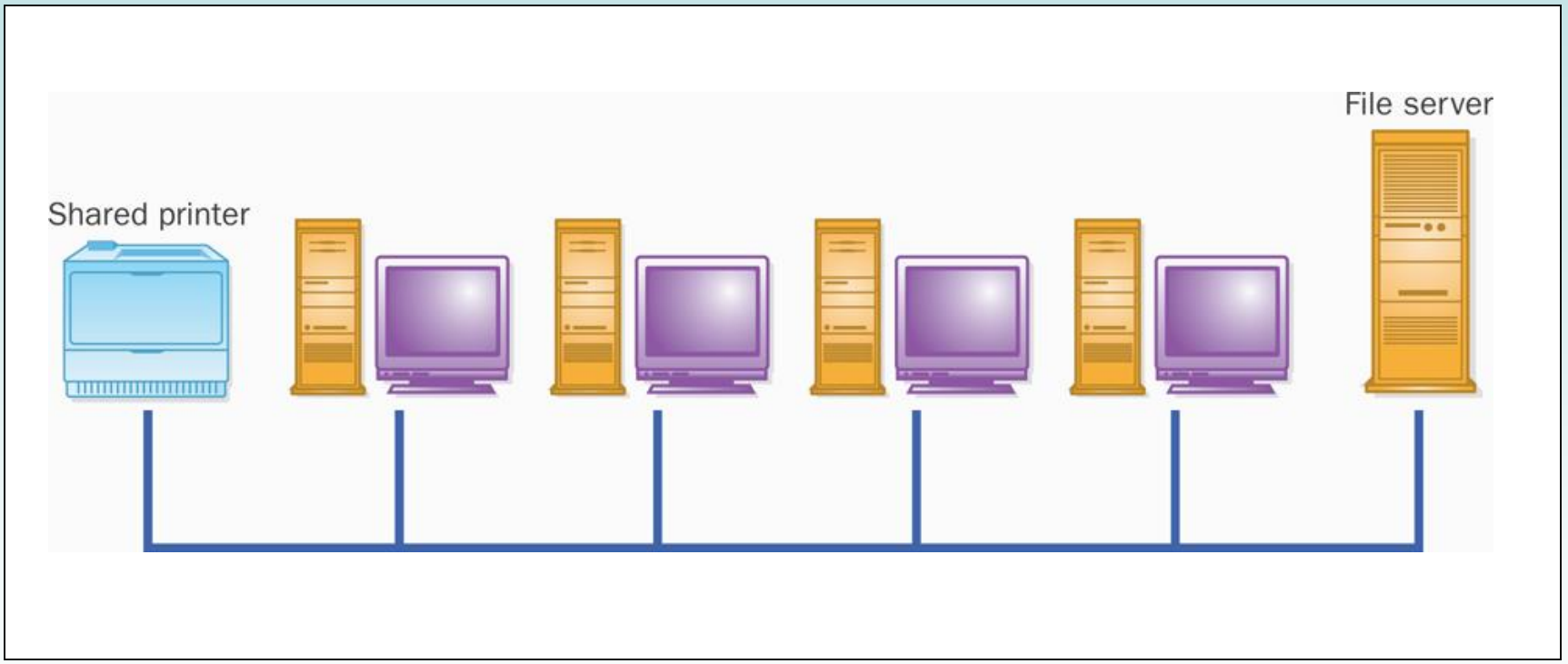
A Computer Network



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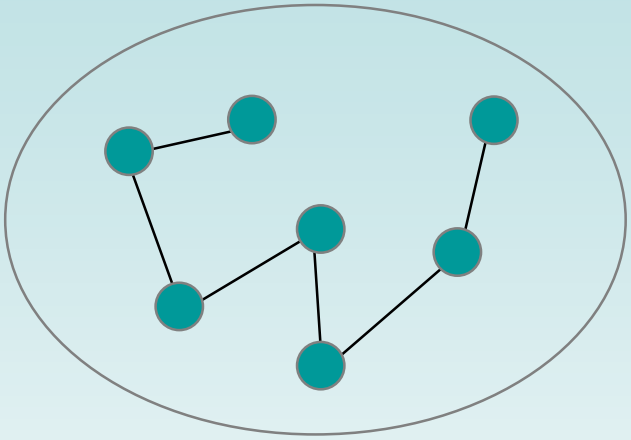
Local-Area Networks

A *Local-Area Network* (LAN) covers a small distance and a small number of computers



LAN

A LAN often connects the machines in a single room or building

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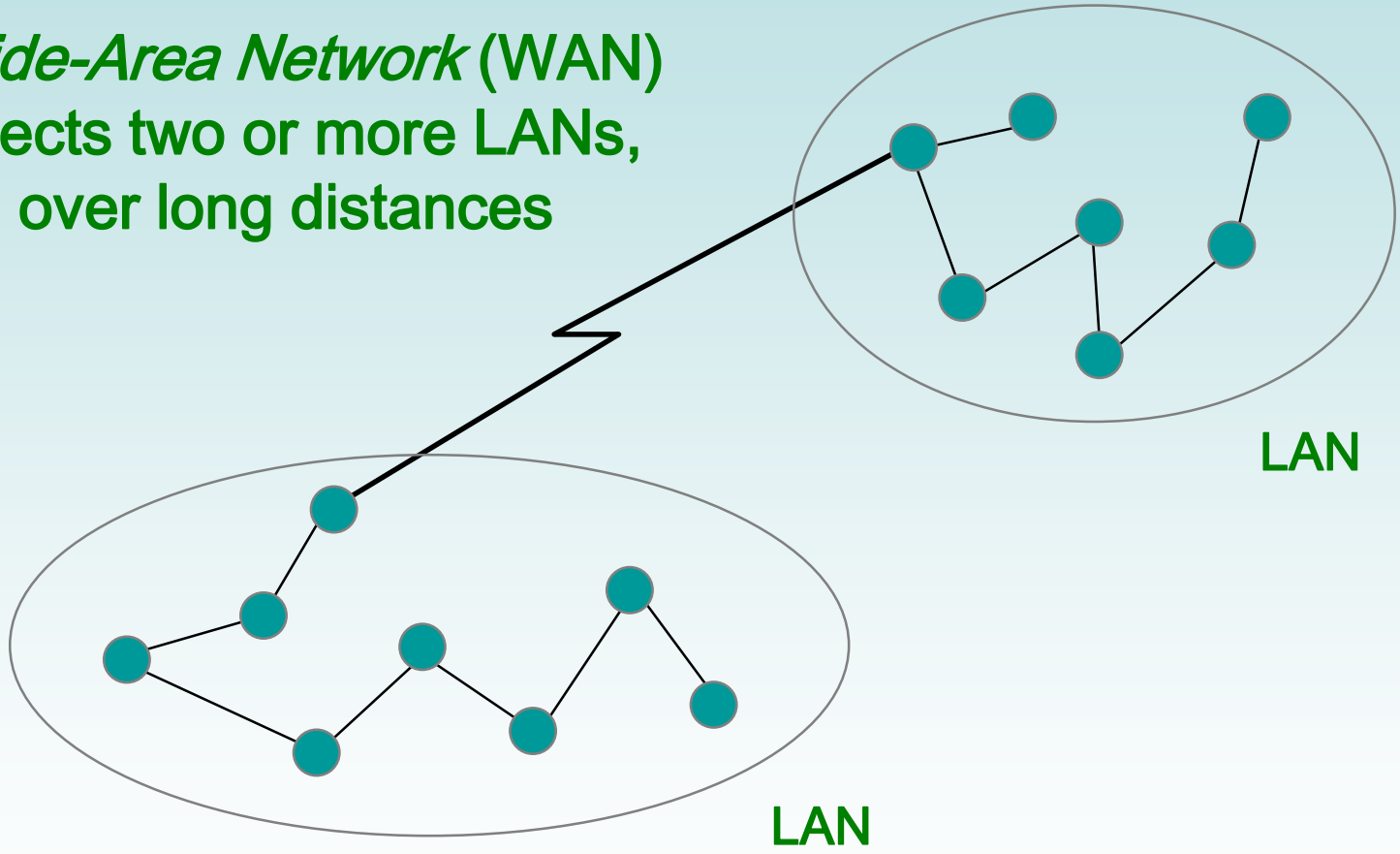
Wide-Area Networks

A *Wide-Area Network* (WAN) connects two or more LANs, often over long distances



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The Internet

- The *Internet* is a WAN which spans the planet
- The word Internet comes from the term *internetworking*
- It started as a United States government project, sponsored by the Advanced Research Projects Agency (ARPA)
  - originally it was called the ARPANET
- The Internet grew quickly throughout the 1980s and 90s

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TCP/IP

- A protocol is a set of rules that determine how things communicate with each other
- The software that manages Internet communication follows a suite of protocols called *TCP/IP*
- The *Internet Protocol* (IP) determines the format of the information as it is transferred
- The *Transmission Control Protocol* (TCP) dictates how messages are reassembled and handles lost information

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IP and Internet Addresses

- Each computer on the Internet has a unique *IP address*, such as:

```
204.192.116.2
```

- Most computers also have a unique Internet name, which also is referred to as an *Internet address*:

```
hector.vt.edu
```

```
kant.gestalt-llc.com
```

- The first part indicates a particular computer (`hector`)
- The rest is the *domain name*, indicating the organization (`vt.edu`)

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Domain Names

- The last part of a domain name, called a *top-level domain* (TLD), supposedly indicates the type of organization:

edu	educational institution
com	commercial entity
org	non-profit organization
net	network-based organization

Sometimes the suffix indicates the country:

uk	United Kingdom
au	Australia
ca	Canada
se	Sweden

Additional TLDs have been added:

biz, info, tv, name

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Domain Names

- A domain name can have several parts
- Unique domain names mean that multiple sites can have individual computers with the same local name
- When used, an Internet address is translated to an IP address by software called the *Domain Name System* (DNS)
- There is no one-to-one correspondence between the sections of an IP address and the sections of an Internet address

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The World Wide Web

- The *World Wide Web* allows many different types of information to be accessed using a common interface
- A *browser* is a program which accesses network resources and presents them
  - Popular browsers: Internet Explorer, Safari, Firefox
- Resources presented include:
  - text, graphics, video, sound, audio, executable programs
- A Web document usually contains *links* to other Web documents, creating a *hypermedia* environment
- The term Web comes from the fact that information is not organized in a linear fashion

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The World Wide Web

- Web documents are often defined using the *HyperText Markup Language* (HTML)
- Information on the Web is found using a *Uniform Resource Locator* (URL):

```
http://www.cnn.com

http://www.vt.edu/student_life/index.html

ftp://java.sun.com/applets/animation.zip
```

- A URL specifies a protocol (http), a domain, and possibly specific documents

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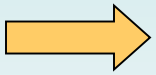

The Java Programming Language

Program Development

Object-Oriented Programming

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Java

- The Java programming language was created by Sun Microsystems, Inc.
- It was introduced in 1995 and it's popularity has grown quickly since
- A *programming language* specifies the words and symbols that we can use to write a program
- A programming language employs a set of rules that dictate how the words and symbols can be put together to form valid *program statements*

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Java Program Structure

- In the Java programming language:
  - A program is made up of one or more *classes*
  - A class contains one or more *methods*
  - A method contains program *statements*
- These terms will be explored in detail throughout the course
- A Java application always contains a method called `main`
- See `Lincoln.java`

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```
//********************************************************************
//  Lincoln.java       Author: Lewis/Loftus
//
//  Demonstrates the basic structure of a Java application.
//********************************************************************

public class Lincoln
{
   //-----------------------------------------------------------------
   //  Prints a presidential quote.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      System.out.println ("A quote by Abraham Lincoln:");

      System.out.println ("Whatever you are, be a good one.");
   }
}
```

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Output

```
A quote by Abraham Lincoln:
Whatever you are, be a good one.
```

```
//********
//  Lincol                                                    **********
//
//  Demons
//*************************************************************************

public class Lincoln
{
   //-----------------------------------------------------------------
   //  Prints a presidential quote.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      System.out.println ("A quote by Abraham Lincoln:");

      System.out.println ("Whatever you are, be a good one.");
   }
}
```

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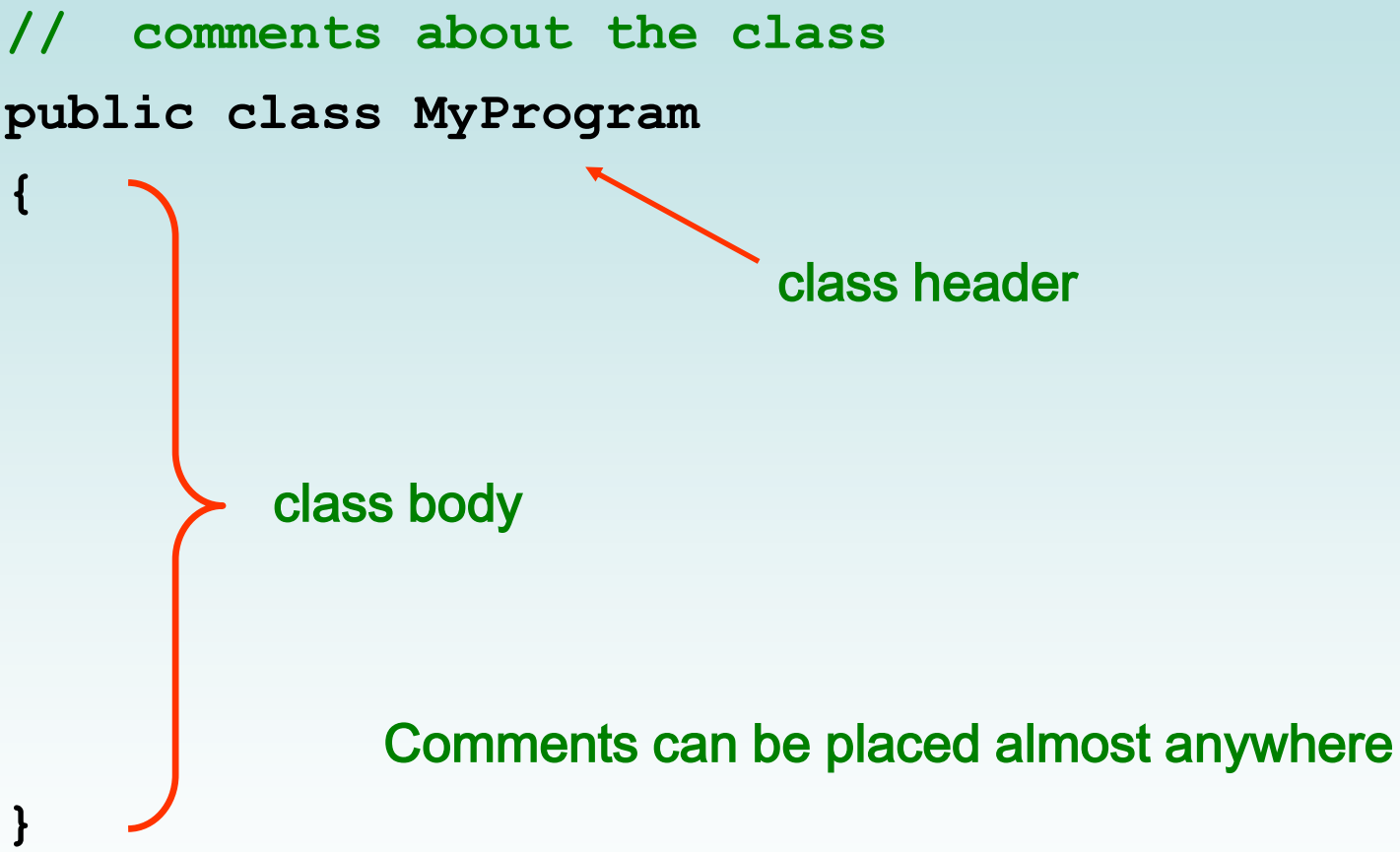
Java Program Structure



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Java Program Structure

```
//  comments about the class
public class MyProgram
{
   //  comments about the method
   public static void main (String[] args)
   {

   }

}
```

method body

method header

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Comments

- Comments should be included to explain the purpose of the program and describe processing steps
- They do not affect how a program works
- Java comments can take three forms:

```
// this comment runs to the end of the line

/*  this comment runs to the terminating
    symbol, even across line breaks        */

/** this is a javadoc comment   */
```

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Identifiers

- *Identifiers* are the "words" in a program
- A Java identifier can be made up of letters, digits, the underscore character (_), and the dollar sign
- Identifiers cannot begin with a digit
- Java is *case sensitive*: `Total`, `total`, and `TOTAL` are different identifiers
- By convention, programmers use different case styles for different types of identifiers, such as
  - *title case* for class names - `Lincoln`
  - *upper case* for constants - `MAXIMUM`

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Identifiers

- Sometimes the programmer chooses the identifer(such as `Lincoln`)
- Sometimes we are using another programmer's code, so we use the identifiers that he or she chose (such as `println`)
- Often we use special identifiers called *reserved words* that already have a predefined meaning in the language
- A reserved word cannot be used in any other way

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Reserved Words

- The Java reserved words:

abstract	**else**	**interface**	**switch**
assert	**enum**	**long**	**synchronized**
boolean	**extends**	**native**	**this**
break	**false**	**new**	**throw**
byte	**final**	**null**	**throws**
case	**finally**	**package**	**transient**
catch	**float**	**private**	**true**
char	**for**	**protected**	**try**
class	**goto**	**public**	**void**
const	**if**	**return**	**volatile**
continue	**implements**	**short**	**while**
default	**import**	**static**	
do	**instanceof**	**strictfp**	
double	**int**	**super**	

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Quick Check

Which of the following are valid Java identifiers?

```
grade

quizGrade

NetworkConnection

frame2

3rdTestScore

MAXIMUM

MIN_CAPACITY

student#

Shelves1&2
```

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Quick Check

Which of the following are valid Java identifiers?

`grade`	Valid
`quizGrade`	Valid
`NetworkConnection`	Valid
`frame2`	Valid
`3rdTestScore`	Invalid – cannot begin with a digit
`MAXIMUM`	Valid
`MIN_CAPACITY`	Valid
`student#`	Invalid – cannot contain the '#' character
`Shelves1&2`	Invalid – cannot contain the '&' character

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White Space

- Spaces, blank lines, and tabs are called *white space*
- White space is used to separate words and symbols in a program
- Extra white space is ignored
- A valid Java program can be formatted many ways
- Programs should be formatted to enhance readability, using consistent indentation
- See `Lincoln2.java` and `Lincoln3.java`

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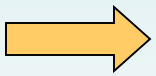
Outline

Computer Processing

Hardware Components

Networks

The Java Programming Language



Program Development

Object-Oriented Programming

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Program Development

- The mechanics of developing a program include several activities:
  - writing the program in a specific programming language (such as Java)
  - translating the program into a form that the computer can execute
  - investigating and fixing various types of errors that can occur
- Software tools can be used to help with all parts of this process

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Language Levels

- There are four programming language levels:
  - machine language
  - assembly language
  - high-level language
  - fourth-generation language
- Each type of CPU has its own specific *machine language*
- The other levels were created to make it easier for a human being to read and write programs

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Programming Languages

- Each type of CPU executes only a particular *machine language*
- A program must be translated into machine language before it can be executed
- A *compiler* is a software tool which translates *source code* into a specific target language
- Sometimes, that target language is the machine language for a particular CPU type
- The Java approach is somewhat different

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Java Translation

- The Java compiler translates Java source code into a special representation called *bytecode*
- Java bytecode is not the machine language for any traditional CPU
- Bytecode is executed by the *Java Virtual Machine* (JVM)
- Therefore Java bytecode is not tied to any particular machine
- Java is considered to be *architecture-neutral*

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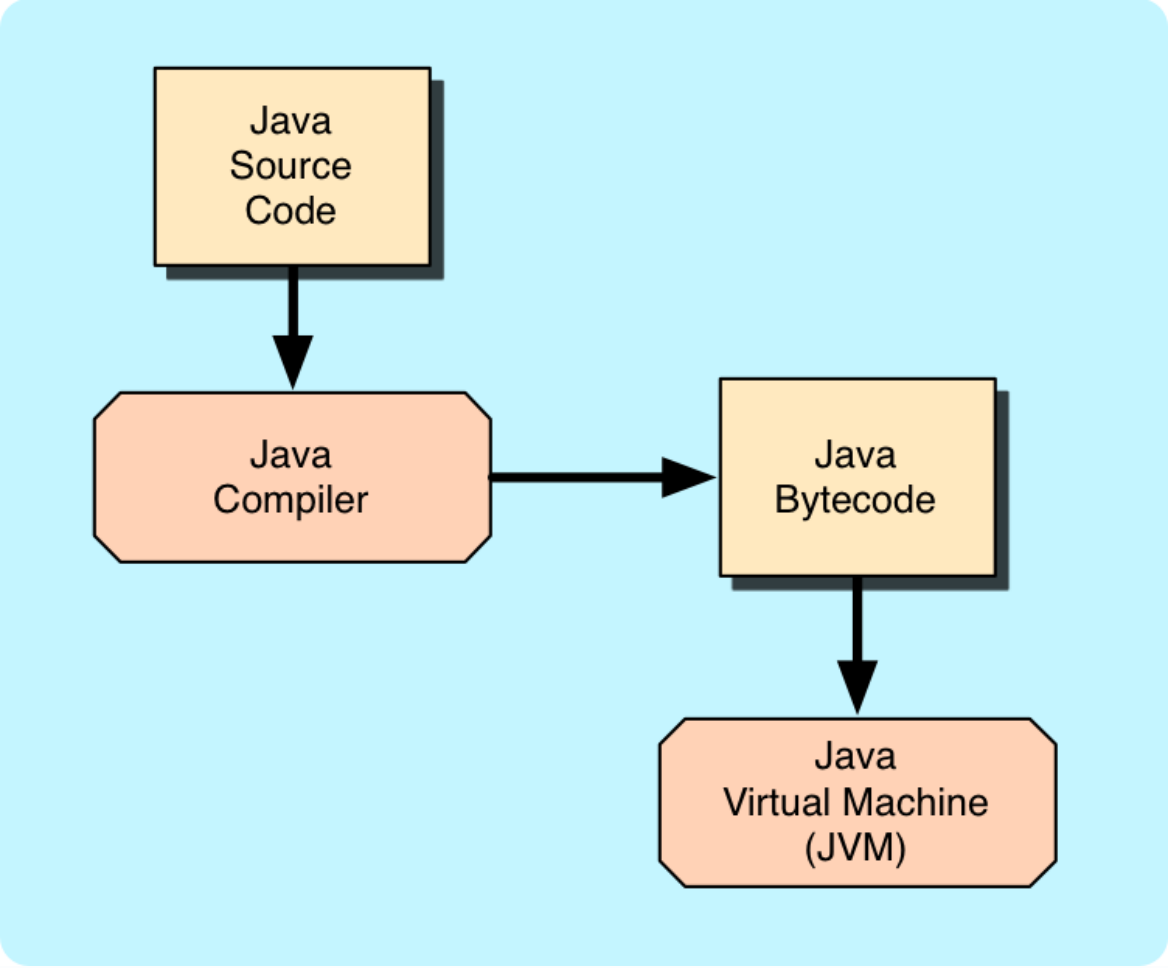
Java Translation



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Development Environments

- There are many programs that support the development of Java software, including:
  - Java Development Kit (JDK)
  - Eclipse
  - NetBeans
  - BlueJ
  - jGRASP
- Though the details of these environments differ, the basic compilation and execution process is essentially the same

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Syntax and Semantics

- The *syntax rules* of a language define how we can put together symbols, reserved words, and identifiers to make a valid program
- The *semantics* of a program statement define what that statement means (its purpose or role in a program)
- A program that is syntactically correct is not necessarily logically (semantically) correct
- A program will always do what we tell it to do, not what we meant to tell it to do

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Errors

- A program can have three types of errors
- The compiler will find syntax errors and other basic problems (*compile-time errors*)
  - If compile-time errors exist, an executable version of the program is not created
- A problem can occur during program execution, such as trying to divide by zero, which causes a program to terminate abnormally (*run-time errors*)
- A program may run, but produce incorrect results, perhaps using an incorrect formula (*logical errors*)

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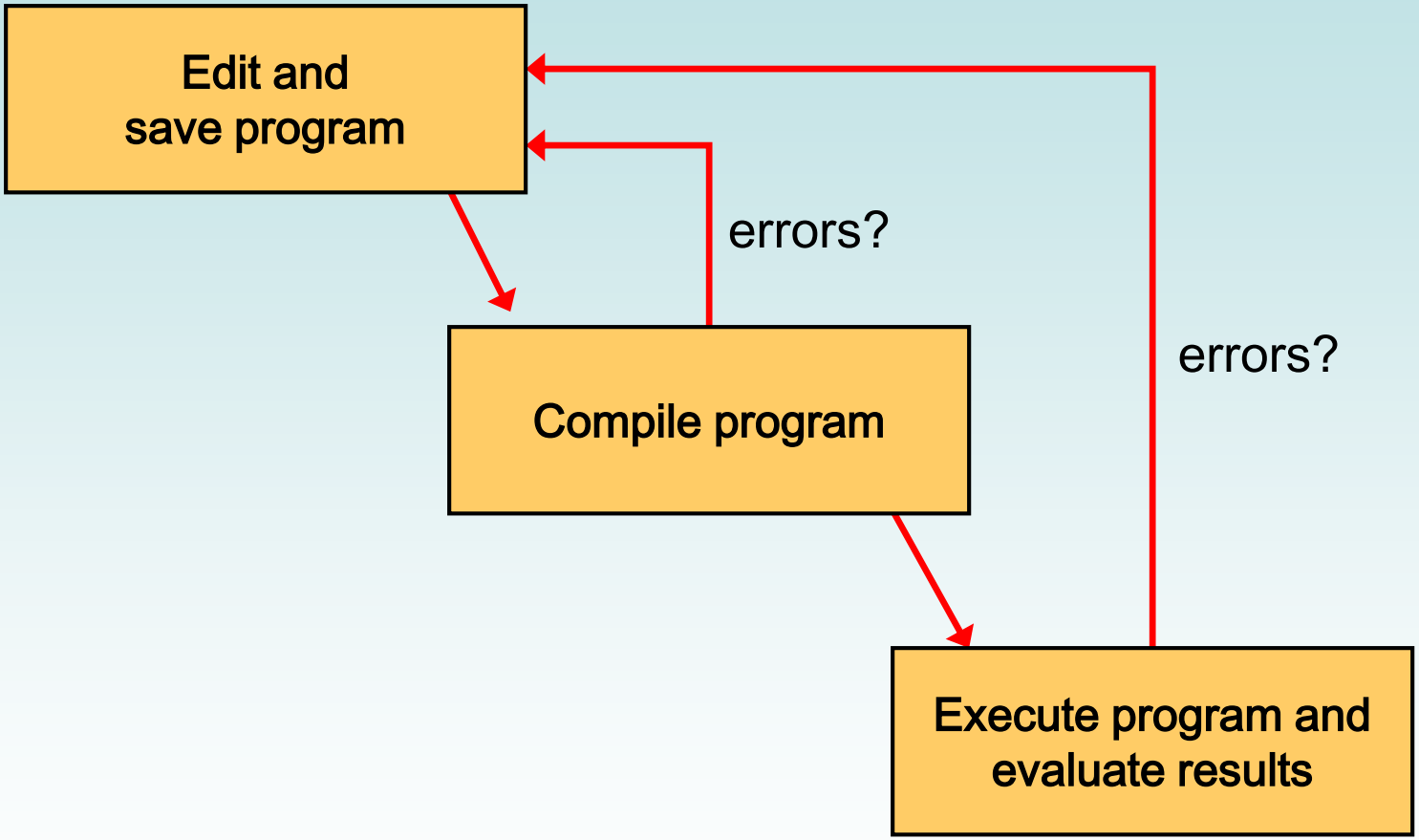
Basic Program Development



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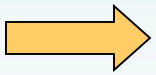

Object-Oriented Programming

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Problem Solving

- The purpose of writing a program is to solve a problem
- Solving a problem consists of multiple activities:
  - Understand the problem
  - Design a solution
  - Consider alternatives and refine the solution
  - Implement the solution
  - Test the solution
- These activities are not purely linear – they overlap and interact

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Problem Solving

- The key to designing a solution is breaking it down into manageable pieces
- When writing software, we design separate pieces that are responsible for certain parts of the solution
- An *object-oriented approach* lends itself to this kind of solution decomposition
- We will dissect our solutions into pieces called objects and classes

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Object-Oriented Programming

- Java is an object-oriented programming language
- As the term implies, an object is a fundamental entity in a Java program
- Objects can be used effectively to represent real-world entities
- For instance, an object might represent a particular employee in a company
- Each employee object handles the processing and data management related to that employee

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Objects

- An object has:
  - *state* - descriptive characteristics
  - *behaviors* - what it can do (or what can be done to it)
- The state of a bank account includes its account number and its current balance
- The behaviors associated with a bank account include the ability to make deposits and withdrawals
- Note that the behavior of an object might change its state

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Classes

- An object is defined by a *class*
- A class is the blueprint of an object
- The class uses methods to define the behaviors of the object
- The class that contains the main method of a Java program represents the entire program
- A class represents a concept, and an object represents the embodiment of that concept
- Multiple objects can be created from the same class

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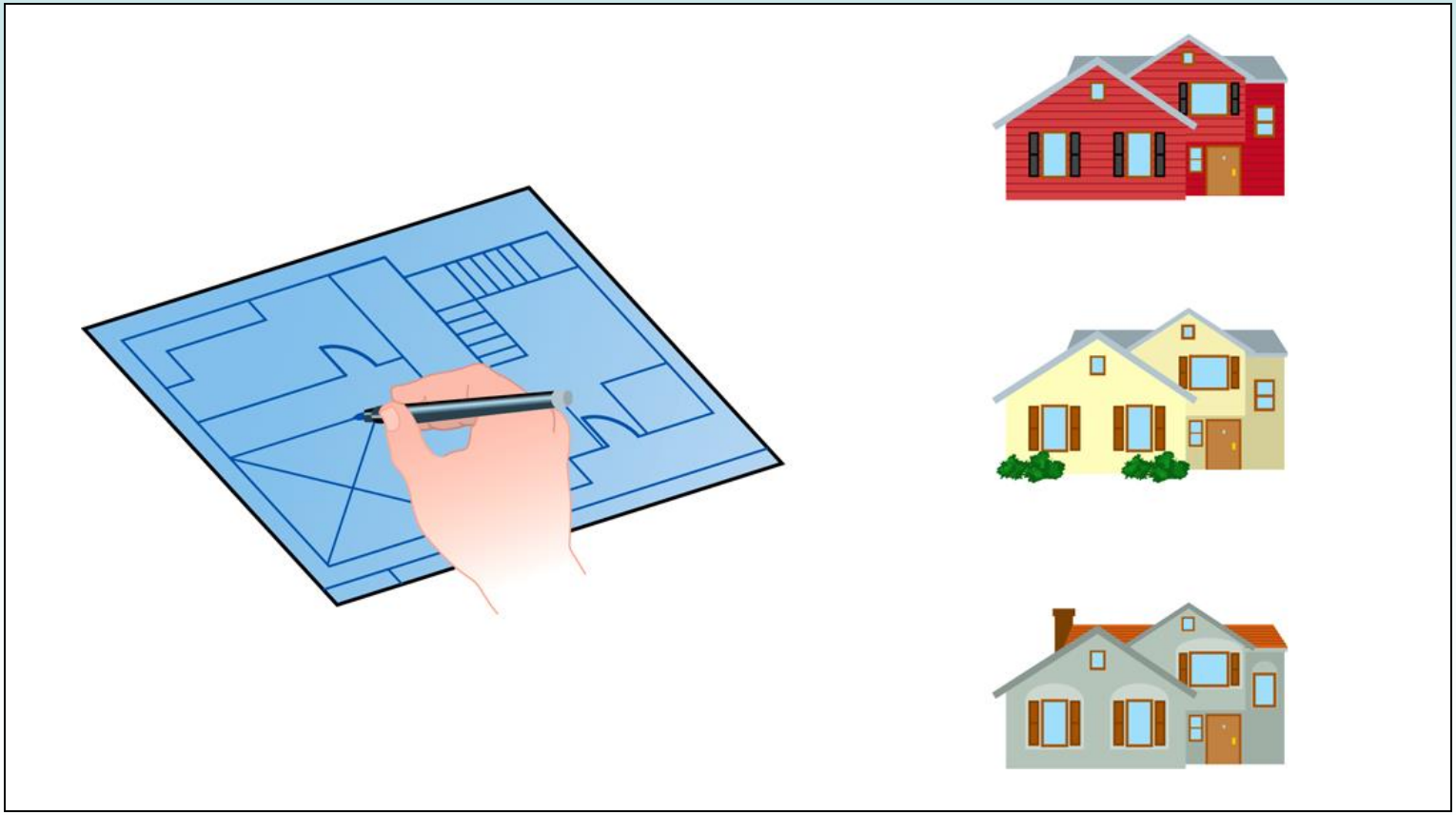
Class = Blueprint

- One blueprint to create several similar, but different, houses:



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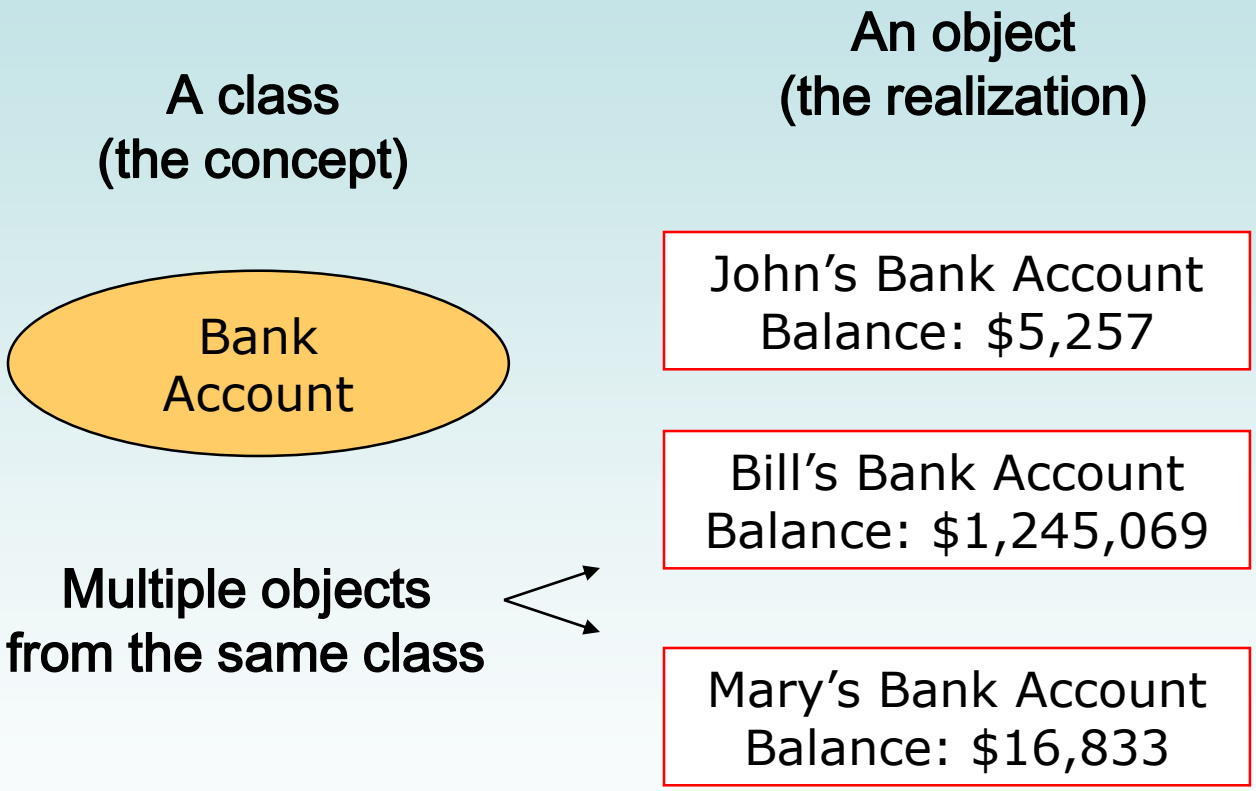
Objects and Classes



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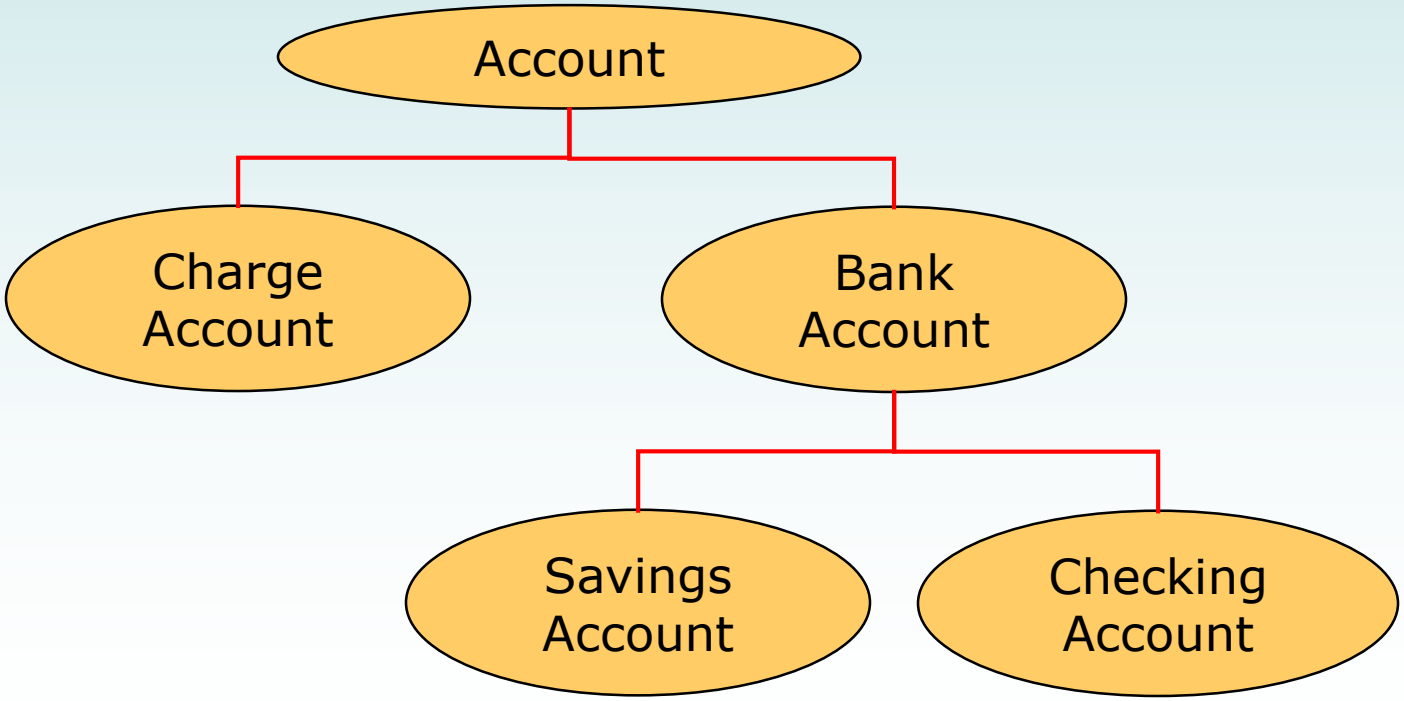
Inheritance

- One class can be used to derive another via *inheritance*
- Classes can be organized into hierarchies



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Summary

- Chapter 1 focused on:
  - components of a computer
  - how those components interact
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages
  - an introduction to Java
  - an overview of object-oriented concepts

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